AN EXAMINATION OF GENDERED DISCOURSE IN THE DISCUSSION FORUMS OF ONLINE STEM COURSES

BY

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DISSERTATION

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Abstract

Women are underrepresented in science, technology, engineering, and mathematics (STEM) fields, a problem that has roots in their disproportional enrollment and retention in STEM courses at the collegiate level. Increasingly, introductory courses across the STEM disciplines are offered online. In this project, I focus on one potential gatekeeper to women's online success: discussion forums.

Although many scholars agree that discussion forums are important components of online courses because of the collaboration and community they foster, there are gaps in our understanding of the mechanisms behind how discussion forums actually do that. One potential mechanism is language; studying the language of discussion forums can help us gain insight into students' state of mind and propensity to form a community. By honing in on specific features of the discussion forums that have the potential to influence students' interactions with one other (i.e., language), I can begin to develop concrete interventions to help students collaborate more effectively, develop community, and ultimately succeed in the course.

The first study of this dissertation describes the state of gendered language use in two online STEM courses. The second paper explores how that language interacts with one way of structuring a discussion forum to predict students' final grades. That structure consisted of giving students the option to post a solution to a homework problem, ask a question, or answer someone's question.

The results reveal that women and men did not differ in their language use along traditionally gendered lines, which is very promising for women in online courses; this means that it is possible that they can feel more comfortable because the language they use does not overtly mark them as a female, and therefore may subvert the typical result of the negative

outcomes associated with that marker. Additionally, although not confined to one's gender, elements of gendered discourse permeated the discussion forums. Gendered language was uniquely used among posting types and also was relevant to students' final grades. Being a male, posting solutions, answering others' questions, having larger word counts, as well as using more numbers and analytic language were all related to earning higher final grades.

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Chapter 1

Introduction

Problem Statement

The need for STEM (Science, Technology, Engineering, and Mathematics)-field graduates is greater than ever, with millions of positions in the United States going unfilled due to gaps in individuals' knowledge and skill sets and the knowledge and skill sets necessary to perform such occupations [National Math and Science Initiative (NMSI), 2014]. Moreover, jobs in STEM fields are projected to grow by 17% by 2023 (Achieve, 2012), making it even more vital to encourage students to enter the STEM arena. To ensure that the STEM workforce not only has enough participants but also is diversified, fostering the possibilities that multiple and diverse perspectives lend to STEM enterprises, it is of utmost importance to focus on recruiting, retaining, and educating underrepresented students in STEM fields. Online courses are one possibility for solving this problem: they have many advantages in terms of cost savings, convenience, and flexibility. Increasingly, introductory courses across the STEM disciplines are offered online and may be students' first college course in their intended major, or first course as they explore a possible STEM major. In this project, I focus on one large underrepresented group in STEM—women—and one potential gatekeeper to their success—their use of discussion forums—in online STEM courses.

Why Study Women in STEM fields?

The demographically disproportional enrollment in STEM courses is a worrisome and challenging problem facing United States colleges and universities. Except for the biological and medical sciences, women are significantly underrepresented in STEM fields. For example, an AAUW (Corbett & Hill, 2015) report claimed that in 2013 "just 12 percent of engineers are

women, and the number of women in computing has fallen from 35 percent in 1990 to just 26 percent today." With less than 25% of women filling all of the STEM jobs in the United States (Beede, et al., 2011), the underrepresentation of women is of national concern (Hernandez, Schultz, Estrada, Woodcock, & Chance, 2013). The breadth of contexts in which women struggle in STEM is apparent from the abundance of studies investigating transitions and attrition along the STEM academic pipeline—from high school to post-secondary education (e.g., Heilbronner, 2013), community colleges to four-year programs (e.g., Jackson, Starobin, & Laanan, 2013), undergraduate programs to graduate school (e.g., Lott, Gardner, & Powers, 2010; Myers & Pavel, 2011), and school to the workplace (e.g., Xu, 2008).

The attrition rate for women in STEM has been attributed to several causes (e.g., Blickenstaff, 2005; Hill, Corbett, St. Rose, & American Association of University Women, 2010). Some explanations point to women assessing themselves lower in their STEM abilities and having higher expectations for success than their male counterparts (e.g., Correll, 2001). Others (e.g., Margolis & Fisher, 2002) reason about a non-inclusive culture in STEM classes, leading to a sense of isolation and a lack of confidence. The discussion forums are one component of online courses that could potentially improve this issue—or exacerbate it. This study will analyze the gendered language used within the forums to gain insight on students' psychological processes (e.g., confidence, doubt, need for affiliations, etc.), which will reveal information about the state of the course's community and students' level of understanding of course material.

Why Study Learning in the Online Space?

Online learning is commonplace for many students, with more than 25% of college students taking an online course during 2014, with every indication that this number continues to

grow every year. Institutions are taking note, eager to develop courses and incorporate them into their long-term strategic plans (Allen, Seaman, Poulin, & Straut, 2016). Although improving *access* through online offerings is important, access is not enough: it is also important that students *succeed* once enrolled. Unfortunately, most studies confirm that attrition rates are far higher in the online environment compared to the face-to-face environment (e.g., Boton & Gregory, 2015; Tyler-Smith, 2006). Even when controlling for student characteristics—including psychological characteristics, prior achievement, and demographics—online attrition rates still linger at rates of 15% higher than that seen in face-to-face courses (e.g., Jaggars & Xu, 2010; Xu & Jaggars, 2011; Zavarella & Ignash, 2009).

There are mixed results in terms of how overall grades differ in online vs. face-to-face environments. Meta-analyses comparing the two environments have concluded that there is no difference, but this is likely because the wide-ranging effects—from face-to-face being superior to online being superior—average to an outcome of no effects (e.g., Bernard et al., 2014). Additionally, many studies measure success in terms of grades without accounting for the two formats' differing drop-out rates (Jaggars, 2011; Phipps & Merisotis, 1999). This is problematic because attrition is much higher in online courses, and those students who drop online courses tend to be those earning the lowest grades. The withdrawal of such students thus automatically raises the overall average grade of the online courses, which does not give an accurate portrayal of achievement in the online environment.

Although the debate about the effectiveness of each format will likely continue for some time, I can agree that understanding why and how the online environment can support student learning is a worthwhile endeavor. Several theories of online learning have emerged in the last

20 years, and studies using these theories have found that certain behaviors, modes of presenting content, and course features *generally* help the online student be successful.

Discussion Forums and Community Formation

Feeling a part of a community is one important component to success in an online course. Substantial work has been devoted to exploring the importance of developing community in online settings to prevent drop-outs (e.g., Liu, Gomez, & Yen, 2009), raise course satisfaction (Drouin, 2008), aid learning (Rovai, 2002), strengthen cooperation (Barab et al., 2001; Hur & Hara, 2007), and increase lines of support (Farooq et al., 2007) as well as feelings of belonging (Besser & Donahue, 1996). Because students learn from each other, as well as from the instructor (e.g., Bell, Grossen, & Perret-Clermont, 1985; Forman & Cazden, 1985), and often feel more connected to the course when they see that other students are having comparable experiences (Freeman, Anderman, & Jensen, 2007), the absence of a community along with feelings of isolation can be detrimental to success in a course, especially in an online course. Although varied, definitions of online communities particularly focus on the strength of members' relationships (e.g., Haythornthwaite & Wellman, 1998). To demonstrate, Bernard and colleagues (2009) found that increasing either one of three types of interaction (student-student, student-content, or student-teacher) increased learner engagement in distance-learning environments, and Jung et al. (2002) also noted that all students showed enhanced engagement with similar interventions. This expands on other studies' findings that students' sense of relatedness among peers increases academic motivation (e.g., Freeman et al., 2007; Furrer & Skinner, 2003; Ostrove & Long, 2007; Walton & Cohen, 2007).

This issue may be especially salient for women, given relatively higher needs for affiliation (Drescher & Schultheiss, 2016). The problem is exacerbated in STEM fields; because

of the paucity of women in these fields, feelings of isolation are more likely. Moreover, the problem is self-perpetuating: the attrition rate for women in STEM programs often has been attributed to isolation (Blickenstaff, 2005; Hill, Corbett, St. Rose, & American Association of University Women, 2010). For example, some explanations (e.g., Margolis & Fisher, 2002) point to a non-inclusive culture in STEM classes, leading to a sense of isolation and a lack of confidence, leading to an exacerbation of the lack of women in STEM.

Online courses have the potential to incorporate features that have the ability to reduce feelings of isolation by promoting communities of learning. For example, forum discussions explicitly tackle the issue of the isolated learner; they not only promote deeper understanding but also may lead to feelings of belonging (Yuan & Kim, 2014). Given discussion forums' potential, this dissertation will focus on the language students use—which can indicate whether they feel like they belong—as well as the types of discussions that may promote deeper understanding. Both variables are important elements to study because of their hypothesized intertwining relationship: the more students feel like they belong, the more they may learn.

Learning from Collaboration

The notion of collaborating to learn has roots in Vygotsky's (1978) theory of social development. Of particular relevance is his concept of the zone of proximal development. The zone of proximal development is the gap between a person's current knowledge when working individually and his/her potential knowledge when receiving assistance. This is a critical concept to Vygotsky's theory, for it provides evidence for his idea that learning is dependent on and the result of others' knowledge. Instruction presents challenging material that ultimately advances a student's mind and encourages the expansion of a student's actual knowledge as well as the knowledge that is in its earliest stages of development.

Roschelle (1992) contends that even without prior knowledge or similar ideas on how to problem solve, two people can work together and capably arrive at a plausible solution. The meaning that they negotiate through conversation creates a conceptual change that becomes shared knowledge. Collaboration is a joint effort in which students build on one another's contributions and learn by taking up one another's ideas (Barron, 2003; Weinberger, Stegmann, & Fischer, 2007).

Online Learning Theories Focused on Collaboration

Moore (1989) was one of the first to recognize that interaction is key to success in distance education, and he identified interaction in three ways: learner-content, learner-teacher, and learner-learner. Research that explores the learner-content interaction has found that, unsurprisingly, students who spend more time with content tend to be more successful than those who do not. Such activities include viewing and posting on discussion forums (e.g., Morris & Finnegan, 2008). Students' interaction with the content is not enough for success in and of itself; the learner-teacher and learner-learner interactions are crucial for developing a deeper understanding of material (Garrison & Cleveland-Innes, 2005).

Garrison, Anderson, and Archer (2000)'s Community of Inquiry (CoI) theory of the online educational experience highlights the need for *others* in learning. Specifically, it states that learning occurs via the interaction of *social presence* (e.g., open communication, group cohesion, and affective expression), *cognitive presence* (e.g., cognitive dissonance and exploration, integration, and application of new ideas), and *teaching presence* (e.g., design, organization, and discourse facilitation). All three elements work together to determine course content, set the climate, and support discourse (Garrison & Arbaugh, 2007). Studies investigating this theory have found that social presence is required for the cognitive presence to

take shape (Celani & Collins, 2005; Hwang & Arbaugh, 2006; Molinari, 2004), but more research needs to explore *how* social presence develops and changes over time and how student characteristics (e.g., gender) influence this development (Garrison & Arbaugh, 2007).

Research Agenda

Although many scholars agree that discussion forums are important components of online courses because of the collaboration and community they foster, there is lacking research on the mechanisms behind how discussion forums actually do that. One potential mechanism is language; studying the language of discussion forums can help us gain insight into students' state of mind and propensity to form a community. By homing in on specific features of the discussion forums that have the potential to influence students' interactions with one other (i.e., language), I can begin to develop concrete interventions to help students collaborate more effectively, develop community, and ultimately succeed in the course.

The forthcoming studies focus on the language that males and females use in the discussion forums of online STEM courses. Specifically, the first paper, found in Chapter 2 and written for at submission to *Language and Education*, describes the state of gendered language in two online STEM courses. The second paper, found in Chapter 3 and written for submission to the proceedings of the 2019 ACM CHI Conference on Human Factors in Computer Systems, explores how that language interacts with one way of structuring a discussion forum to predict final grade. The motivations, theoretical foundations, and literature reviews for each of the studies precedes each paper. Finally, Chapter 4 contains future directions for studying language as well as other components of discussion forums that can help women be more successful in their endeavors with online STEM courses.

Chapter 2

Gender and Gendered Discourse in Online STEM Courses

Introduction

The need for STEM (Science, Technology, Engineering, and Mathematics)-field graduates is greater than ever. STEM jobs have grown by 14% since 2008, compared to 1.4% for non-STEM jobs, and they are expected to grow another 8.9% by 2024; along with the greater need comes greater salaries, with STEM workers earning 29% more than non-STEM workers (Noonan, 2017). Although these factors should make STEM careers alluring pursuits, STEM positions in the United States are going unfilled due to gaps in individuals' knowledge and skill sets necessary to perform these jobs [National Math and Science Initiative (NMSI), 2014].

Women, in particular, are shying away from STEM positions, as they make up only 24% of the STEM workforce (Noonan, 2017). To ensure that the STEM workforce not only has enough participants but also is diversified—thereby fostering the possibilities that multiple and diverse perspectives are available to STEM enterprises—it is of utmost importance to focus on recruiting, retaining, and educating underrepresented students in STEM fields. Online courses are one possibility for solving this problem because these courses currently are widespread in STEM programs that lead to baccalaureate degrees and allow for students to control more of when, where, and how they participate, thereby potentially mitigating some of the barriers to success for underrepresented STEM students in face-to-face STEM courses. This study will examine one mechanism, which is both likely influential and typically available to analyze, on women's success in online courses: the language used in class discussion forums. Students' language in class discussion forums was chosen as the key mechanism because this can be a

marker of their social status (i.e., gender), and thus these markers have the potential to impact how and with whom they share information in the online environment (Cho, Gay, Davidson, and Ingraffea, 2005).

Literature Review

Women in STEM Fields

The demographically disproportionate enrollment in STEM courses is a worrisome and challenging problem facing United States colleges and universities. Except for the biological and medical sciences, women are significantly underrepresented in STEM fields (Corbett & Hill, 2015). The breadth of contexts in which women struggle in STEM is apparent from the abundance of studies investigating transitions out of and attrition from the STEM academic pipeline (e.g., Heilbronner, 2013; Jackson, Starobin, & Laanan, 2013; Myers & Pavel, 2011; Xu, 2008).

The attrition rate for women in STEM has been attributed to several causes (e.g., Blickenstaff, 2005; Hill, Corbett, St. Rose, & American Association of University Women, 2010). Some explanations point to women assessing themselves lower in their STEM abilities and having higher expectations for success than their male counterparts (e.g., Correll, 2001). When this is the case, it is easy for women to opt out because they get defeated more easily than men. Other researchers (e.g., Margolis & Fisher, 2002) reason about a non-inclusive culture in STEM classes, leading to a sense of isolation and a lack of confidence. These two explanations can also conspire to work against women staying and succeeding in STEM: a non-inclusive culture, isolation, and lack of confidence puts women at risk of not having the necessary supports when they feel like they haven't succeeded at the level of their male peers.

Feeling a part of a community is one important component to success in any course, and online courses are no exception. Because students learn from each other, as well as from the instructor (e.g., Bell, Grossen, & Perret-Clermont, 1985; Forman & Cazden, 1985), and often feel more connected to the course when they see that other students are having comparable experiences (Freeman, Anderman, & Jensen, 2007), the absence of a community along with feelings of isolation can be detrimental to success in a course, especially in an online course. Because of the potentially increased risk in online courses (of vulnerability to feelings of isolation, leading to feelings of failure, leading to women's attrition in STEM) and the draw of women to online courses (given the convenience and increasing ubiquity of online offerings), this study will examine a potential mechanism for hindering or helping women's sense of belonging and confidence in the online space: the language used in the online courses' discussion forums. Language has the potential not only to be a marker of one's social status (i.e., gender), but also to have an impact on the collaborative experience by way of influencing how and with whom students share information in the online environment (Cho, Gay, Davidson, and Ingraffea, 2005).

Women Perform Differently than Men in Online Courses

Although Xu and Jaggars (2014) found that women were outperforming men in the online environment, they noted that women in online classes still did not perform as well as women in face-to-face classes. Wladis et al. (2015) found even more dire results when focusing only on online STEM courses: even though women are overrepresented in online STEM courses, they are more likely to fail and withdraw than men. Likewise, Cochran, Campbell, Baker, and Leeds (2014) found that women who were majoring in math or science fields withdrew from online courses more so than men in these fields. Research on how women perform in STEM

online courses at four-year institutions, in particular, is lacking, although Wladis et al. (e.g., Hachey, Wladis, & Conway, 2015; Wladis et al., 2015) are advancing the development of online models of success for STEM courses in community colleges. To shed light on this problem, this study will contribute to advancing an understanding of how women in online STEM courses in four-year institutions.

Language: A Potential Mechanism for Online Course Success

Numerous fields, including psychology, linguistics, communications, anthropology, and sociology, have investigated the ways in which self-identified males and self-identified females use language. The consensus is that, although more similar than not, there are measurable differences in men and women's use of certain features of language (Canary & Dindia, 2009). Patterned differences in words, phrases, and sentences have led researchers to categorize men's communication as generally dominant and aggressive and packed with information (a "report" style of communicating) and women's communication as generally submissive and affiliative (a "rapport" style of communicating) (Tannen, 2007). Importantly, these styles signify power differences, leading to real-world power differentials between men and women in both the private and public spheres (Hall, 2004; McConnell-Ginet, 2004).

Given that students taking up and owning ideas from others is an important part to learning (e.g., Barron, 2000, 2003), examining the language used to share those ideas is crucial. If a student who has a more communal style of discourse gets in a discussion with someone who is more aggressive, that student may feel attacked and belittled—ultimately making that student want to stop participating and engaging. Alternatively, a student who exhibits more rapport-building language patterns may attract students who feel confused and have questions, therefore building a safe place for help-seekers to express their concerns and assist one another. This study

will begin to examine the role of language because of its crucial role in promoting or hindering community building by investigating the types of gendered discourse used in two online STEM courses' discussion forums.

The categories chosen for this research derive from Tannnen's (1990) work and were used to shape Newman, Groom, Hanelman, and Pennebaker's (2008) analysis of gendered language in a variety of contexts. In particular, this study examines:

(a) pronouns. Women tend to use more pronouns than men; pronouns implicitly require shared understanding and meaning, thus highlighting a closeness between discussants.

(b) politeness. Women's language tends to be more polite in nature than men's.

(c) hedging. This vague language that avoids definitiveness tends to be associated with women.

(d) personal and interpersonal queries. Women tend to focus more on others than men do when communicating.

(e) information giving. Men tend to focus on relaying facts more so than women.

(f) confidence. Men tend to portray more confidence in their language than women.

Research Questions

In this study, I aim to advance an understanding of how gendered language is used by men and women in ways that potentially help or hinder community building in two online courses from different STEM disciplines. I will do so by examining the language that students use, with special attention to whether men and women use traditionally gendered language. Specifically, I ask:

1) To what extent do men use a report style of communicating and do women use a rapport style of communicating in an online chemistry course?

2) To what extent do men use a report style of communicating and do women use a rapport style of communicating in an online astronomy course?
3) When comparing the two courses, to what extent is the language used similar and different?

Methods and Data Sources

Data Set

Chemistry. Data were collected from the discussion assignments from the Fall 2015, Spring 2016, Summer 2016, and Fall 2016 semesters of an introductory online chemistry course offered at a large Midwest university. In each semester, there were a total of 13 discussion assignments, one for each week of material; students had to participate each week if they wanted to earn the full 5% of the final grade that was allocated for discussion assignments. The assignments entailed the following: Each week, the instructor created 4-5 discussions forums, with each forum consisting of an exam-like homework problem. The students could choose to post to any of the of the available forums for that week, and then they had to (a) post a solution to the problem, (b) post a question, or (c) answer a question. Students were required to do only one of the aforementioned activities and on only one of the forums each week, although they were welcome to participate more if they chose to do so. The instructor's intended goal of this assignment, as posted on the syllabus, was to have students "learn how to approach challenging problems from other student explanations, and by teaching other students."

Astronomy. Data were also collected from the discussion forums from the Fall 2016 semester of an upper-level online astronomy course. Like the chemistry course, weekly forum participation in the discussion forum was required. Participation in at least 10 of the forums constituted 25% of students' grades (compared to only 5% of students' grades in Chemistry).

The stated goal of the forums, according to the syllabus, was "to discuss class facts to better understand the science…" Students were required to post a response to a topic and post at least two responses to other students' postings.

Participants

Accounting for all four semesters of chemistry, there were 368 total students enrolled, only 345 of whom were unique enrollees. (Eighteen students had enrolled in two semesters and three students had enrolled in three semesters). There were 74 total drops, but because there were eight students who had dropped the course twice across the four semesters, there were only 66 unique students who dropped (37 women and 29 men). This left 271 unique students who were enrolled for the entire semester. I had incomplete date for 24 of the students, leaving a total of 247 students for analysis (132 women and 115 men). The astronomy course began with a total of 209 students (53 women and 156 men). A total of 8 students (2 women and 6 men) dropped, leaving 51 women and 150 men enrolled by the end of the semesters.

A Center for Innovation in Teaching and Learning (CITL) staff member with clearance to access FERPA-protected data took the discussion posts and replaced any personally identifiable information with a random hash and created a key detailing the gender that corresponded with each of the random hashes. The chemistry students generated 3,404 unique posts throughout the four semesters under investigation, and the astronomy students generated 12,590 unique posts.

Text Analysis

To analyze the gendered language employed in the discussion forums, I used Linguistic Inquiry and Word Count 2015 (LIWC; Pennebaker, Booth, Boyd, & Francis, 2015), a computerized text analysis program in its third iteration that outputs the percentage of words in a given text that fall into one or more of over 80 linguistic (e.g., pronouns, conjunctions),

psychological (e.g., anger, achievement), and topical categories (e.g., health, religion). Its corpus consists of more than 500,000 texts that range from tweets to novels. A major addition to the 2015 version of LIWC is the inclusion of four summary variables empirically developed in the research labs of the LIWC team: *Analytical Thinking* (Pennebaker et al., 2014), *Clout* (Kacewicz et al., 2012), *Authenticity* (Newman et al., 2003), and *Emotional Tone* (Cohn et al., 2004). Based on the relation to previous research, this study focused on *Analytic Thinking* (e.g., critical thinking and logical thinking), *Clout* (e.g., confidence and expertise), and *Authenticity* (e.g., openness and honesty). LIWC generates a rating for each of these summary categories.

I chose this application in part because of its wide-spread usage, because exploring trends within studies of gendered language is often difficult due to the varied meanings and understandings of what constitutes gendered language (Newman, Groom, Handelman, & Pennebaker, 2008). A program as ubiquitously used and updated as LIWC can help systematize the study of gendered language. As such, this study builds on Newman et al.'s (2008) use of LIWC 2001 to analyze gendered language.

Results

The LIWC output generated frequencies for the *Word Count* category, ratings for the *Authentic*, *Analytic*, and *Clout* categories, and percentages for the *Pronouns*, *Discrepancies*, *Tentative*, *Social Processes*, *Numbers*, and *Certainty* categories. To perform analyses on these data, I transformed the percentages into counts. Table 1 delineates the relationship between the LIWC categories and the gendered language categories explored in previous research, which I also examined here.

The following is an exploration of each gender's use of the aforementioned LIWC categories for each course. Table 2 contains the median counts for each of the LIWC categories

by gender across semesters for chemistry, and Table 3 contains the median count for each of the LIWC categories by gender for astronomy. Table 4 compares the median counts of the LIWC Categories for each of the courses.

LIWC Categories and Gender in Chemistry

To answer the first research question—To what extent do men use a report style of communicating and do women use a rapport style of communicating in an online chemistry course?—I examined the language used by men and women in their posts, using linguistic, psychological, and summary categories generated by LIWC.

Linguistic categories. I conducted a nonparametric independent samples median test, specifically the Kruskal-Wallis one-way analysis of variance test, on the word counts of men's and women's posts to understand their information-sharing tendencies. I found no significant difference between the number of words produced in men's and women's discussion forum posts.

Next, as an indication of familiarity, I examined the use of pronouns in the discussion forum posts: using a pronoun can indicate that the reader knows who or what the writer is referring to. I did not find a significant difference between men and women in their use of pronouns.

Psychological categories. I used the Kruskal-Wallis one-way analysis of variance test on all psychological categories. Two of the three measures of personal and interpersonal queries (*Social Process* and *Affiliation*) fell into psychological categories, and neither were significant. *Tentative*, which implies uncertainty and hedging through words like *maybe* and *perhaps*, was also not significant. Similarly, *Certainty*, which implies absolutes and confidence through words like *always* and *never*, was also not significant. *Discrepancy*, which indicates politeness through

words like *would* and *could*, was not significant either. Finally, I tested men's and women's use of numbers to investigate how many times numbers were incorporated into discourse. This, too, was not significant.

Summary categories. I also used the Kruskal-Wallis one-way analysis of variance test to analyze the summary categories of *Analytic*, *Authenticity*, and *Clout*. *Analytic* language was used as a means of indicating information sharing; *Authenticity* was used to denote personal and interpersonal inquiries; and *Clout* was used to understand confidence. Men did not demonstrate analytic reasoning significantly more than women, nor did women demonstrate authenticity significantly more than men. There were no significant differences between men and women in showcasing clout.

In summary, I found no differences between men and women's use of language in any of the categories I examined. Next, I analyzed whether these same findings held for another STEM course, an upper-level astronomy class.

LIWC Categories and Gender in Astronomy

To answer the second research question—To what extent do men use a report style of communicating and do women use a rapport style of communicating in an online astronomy course?—I conducted the same analyses I conducted on the data from the online chemistry course..

Linguistic categories. Using the Kruskal-Wallis one-way analysis of variance test, I found no significant difference between the number of words produced in men's and women's discussion forum posts. The same was true for use of pronouns.

Psychological categories. The Kruskal-Wallis one-way analysis of variance test was used for all psychological categories. *Social Process*, *Affiliation, Certainty, Discrepancy,* and *Numbers* were

not significant between men and women. *Tentative* was the only significant category, with men using such words more than women, $\chi^2(1) = 4.068$, $p < .05$.

Summary categories. I also used the Kruskal-Wallis one-way analysis of variance test to analyze the summary categories of *Analytic*, *Authenticity*, and *Clout*. There were no significant differences between men and women in their use of any of these categories.

With the exception of *Tentative*, I found no differences between men and women's use of language in any of the categories I examined, which parallels the results found for the chemistry course.

Differences in Gendered Language Use, Between Courses

Because I did not find differences between men's and women's use of gendered language, I wondered whether the use of gendered language might be different across the two courses. This was possible given the differences in content, in how the discussion forums were organized, and how much weight the discussion forum posts had towards students' final grades. This led to the third research question: When comparing the two courses, to what extent is the language used similar and to what extent is it different?

Linguistic categories. The Kruskal-Wallis one-way analysis of variance test revealed a significant difference in the word counts between the two courses. Specifically, the average word count of the posts in the astronomy discussion forums was significantly higher than that of chemistry, $\chi^2(1) = 7.669$, $p < .01$. Pronouns, however, were used significantly more frequently in the chemistry course than in the astronomy course, $\chi^2(1) = 161.645$, $p < .01$.

Psychological categories. The Kruskal-Wallis one-way analysis of variance test was used for all psychological categories, and all of these categories were significant. In all cases, students in the chemistry course used language pertaining to these categories significantly more

than in the astronomy course: *Social Process*, $\chi^2(1) = 145.570$, $p < .01$; *Affiliation,* $\chi^2(1) = 80.891$, $p < .01$, *Certainty,* $\chi^2(1) = 229.502$, $p < .01$; *Discrepancy,* $\chi^2(1) = 221.907$, $p < .01$; *Tentative,* $\chi^2(1) = 168.585$, $p < .01$; and *Numbers,* $\chi^2(1) = 264.631$, $p < .01$.

Summary categories. Finally, using the Kruskal-Wallis one-way analysis of variance, I found that all of the summary categories were significantly different between the two courses. Although the posts in the chemistry course were significantly more *Analytic*, $\chi^2(1) = 90.274$, $p < .01$, the posts in the astronomy course displayed significantly more *Authenticity*, $\chi^2(1) = 183.362$, $p < .01$, and *Clout,* $\chi^2(1) = 46.481$, $p < .01$.

Although there were not significant differences in the use of gendered language between males and females, gendered language is still being used within each course. Each course is using gendered language in very different ways, though, which is discussed in the following section.

Discussion

Online courses have the potential to incorporate features that have the ability to reduce students' feelings of isolation. Forum discussions explicitly tackle the issue of the isolated learner, by not only promoting deeper understanding but also helping to develop feelings of belonging (Yuan & Kim, 2014). This study revealed that females and males did not differ in their language use along traditionally gendered lines. In other words, females did not use more rapport language than males, and, likewise, males did not use more report language than females. This finding is very promising for females in online courses, because this means that it is possible that they can feel more comfortable because the language they use does not overtly mark them as a female, and therefore may subvert the typical result of the negative outcomes associated with that marker. Additionally, by not strictly adhering to using language traditionally associated with

women, women are more likely to be heard and have their ideas considered (Tannen, 1995). This attention to women's insights has the ability to influence positively learning for all, so it is promising that the online environment might serve as a conduit for getting women's ideas taken seriously.

Although not used strictly along gendered lines, gendered language was used within each course; the extent to which students used gendered language varied by course, though. Of note is that students' posts in the chemistry course had higher *Analytic* ratings and greater use of *Numbers* than students in the astronomy course. Students in the chemistry course also used more community-building language than students in the astronomy course, by way of using more *Social* and *Affiliation* words as well as politeness indicators through the *Discrepancy* category. This indicates that students in the chemistry course may feel more connected to one another than the students in the astronomy course.

I found differences in the average word length between the two courses, which implies a difference in the amount of information being shared. Although it is not possible for us to know why this was the case, I can hypothesize that because the astronomy course put more weight on discussion posts (25%) than the chemistry course (5%), this may have influenced students to write more. This can be tested in the future with other online courses that assign different weights to the discussion posts. It will be interesting to see whether the importance implied by the effect on final grade impacts students' length of posts in other courses in ways similar to those documented here. In addition, I are curious about the relation between length of post and student learning. This issue, too, will have to be taken up in future investigations.

Interestingly, students in the chemistry course simultaneously used more *Certainty* language and *Tentative* language compared to the astronomy students. While this at first may

appear to be contradictory, the structure of the chemistry course provides insight for this outcome. Within the chemistry course, students participated in the forums by posting in three ways: posting a solution to a homework problem, asking a question, or answering someone's question. Thus, it could very well be that language use corresponds with posting type. For example, perhaps students who ask questions lack confidence—as demonstrated through their use of hedges in the *Tentative* word category—while students who answer others' questions showcase high levels of *Certainty*. Future work needs to examine how posting type is related to language use.

Although I have no confirmatory data, I can hypothesize that, because the chemistry course and astronomy course were structured very differently, the course structures may have influenced differential use of gendered language. For example, *requiring* students to respond to others' posts in the astronomy course (while only making it an option in the chemistry course) may have generated more dialogue and conversation between participants; this type of back-and-forth discussion may be what generates gendered language. Future investigations that have access to a larger number of courses with structures similar to the chemistry course and astronomy course could begin to unravel the relation between how course structures influence students' use of gendered language forms.

From this study, it is unclear whether particular language choices were more productive (in terms of final grade, course retention, feelings of belonging, etc.); it is worth asking whether and how students' language needs to be tailored to the discussion forum's structure. For example, it may be advantageous to use more communal language and let one's guard down when posting questions than when asking questions. Using phrases like "I think" and "maybe" imply uncertainty, but, when asking questions, students indeed are often uncertain and that is

why they are seeking help. By coming across as rather humble, these students may attract more students who are willing to answer their questions, which likely bodes well for productive dialogue and community building. On the other hand, using words associated with certainty may be useful when posting a solution or an answer to someone's question. That certainty may give the content more credibility to others who may be learning from it, and may encourage students to continue to ask questions when they know they will be getting solid, confident feedback. This, in turn, may promote dialogue and community. Thus, future work should investigate the extent to which differences in language use are related to the ways in which the discussion forums are structured, as well as the extent to which certain types of language forms (e.g., hedging vs. certainty) are related to outcomes of success (e.g., final grade, course retention, feelings of belonging, etc.) within and between various discussion forum structures.

Of course, the structure of the course may be only loosely related or even unrelated to language choices. Rather, the course itself may be more relevant for dictating the language used. This study compared an introductory-level STEM course (chemistry), which is *required* for an array of majors, to a more advanced-level STEM course (astronomy), which is an *elective* for several STEM majors. Compared to the astronomy course, the chemistry course focused on more foundational material that potentially covered material that some students may have learned in high school. Thus, many students in the chemistry course may be more confident in their knowledge of the material and thus may be more willing to share their knowledge in a helpful, communal, collegial way. Future work should compare several introductory-level STEM courses with one another and several upper-level STEM courses with one another, to see if the language varies as much as it did in this study, to begin to tease out whether the differences observed in this investigation might be a function of the level of the course. Furthermore,

examining the interplay of students' backgrounds (e.g., previous coursework, reasons for taking the course, ACT score, GPA, experience with technology, etc.) will also be valuable, as these variables may very well moderate language use. For example, students who have taken a similar course previously likely may engage in more information sharing.

Conclusion

That men and women did not use gendered language across gendered lines is somewhat surprising but is also promising. The lack of use of gendered language between males and females means, at least for these courses, that this marker of gender did not differentiate men from women, and thus did not advantage or disadvantage students based on their gender in the online environment. It is possible that, without gendered language to distinguish men from women, at least one potential barrier for females to succeed in the online environment was absent. Strikingly, even though there were no gender differences in use of gendered language, I found differences between the two courses examined here. The language differences between the two courses highlight the need to study the role of language more when analyzing online course discussion forums; researchers and practitioners alike need a better understanding of language's influence in the online environment so that discussion forums—the area of the online environment most crucial to community building—can be as productive as possible for all students.

Tables

Table 1
LIWC Categories Used in this Investigation

Previous Findings	Relevant LIWC Categories	Finding reported by:
Word Count M>F	Word Count	Newman et al., 2008
Pronouns F>M	Total Pronouns	Newman et al., 2008
Politeness F>M	Discrepancies	Tannen, 1990
Hedging F>M	Tentative	Tannen, 1990
Personal/interpersonal queries F>M	Social Processes Words; Authentic; Affiliation	Tannen, 1990
Information Giving M>F	Numbers; Analytic	Tannen, 1990
Confidence M>F	Clout; Certainty	Tannen, 1990

Table 2
Median Counts of LIWC Categories by Gender—Chemistry

LIWC Category	*M*dn	*p* value
Word Count		.439
Men	451.0	
Women	424.0	
Analytic		.186
Men	86.5	
Women	84.4	
Clout		.550
Men	48.4	
Women	49.7	
Authentic		.776
Men	9.5	
Women	9.5	
Pronoun		.554
Men	29.0	
Women	20.5	
Number		.488
Men	63.0	
Women	60.0	
Social		.862
Men	12.0	
Women	12.0	

Table 2 Continued

Discrepancy		.773
Men	4.0	
Women	4.0	
Tentative		.965
Men	7.0	
Women	6.0	
Certainty		.418
Men	4.0	
Women	4.0	
Affiliation		.486
Men	6.0	
Women	4.0	
Question Mark		.334
Men	1.0	
Women	1.0	

Table 3

Median Counts of LIWC Categories by Gender—Astronomy

LIWC Category	*M*dn	*p* value
Word Count		.534
Men	500.0	
Women	540.0	
Analytic		.591
Men	67.6	
Women	65.7	
Clout		1.37
Men	58.2	
Women	60.5	
Authentic		.932
Men	49.3	
Women	49.0	
Pronoun		.578
Men	3.0	
Women	3.0	
Number		.964
Men	1.0	
Women	1.0	
Social		.484
Men	1.0	
Women	1.0	
Discrepancy		.158
Men	0.0	
Women	0.0	

Table 3 Continued

Tentative*		.044
Men	1.0	
Women	0.0	
Certainty		.367
Men	0.0	
Women	0.0	
Affiliation		.153
Men	1.0	
Women	1.0	
Question Mark		.652
Men	0.0	
Women	0.0	

* $p < .05$.

Table 4

Median Counts of LIWC Categories by Course

LIWC Category	*M*dn	*p* value
Word Count*		.006
Chemistry	433.0	
Astronomy	512.0	
Analytic*		.000
Chemistry	85.8	
Astronomy	67.1	
Clout*		.000
Chemistry	48.9	
Astronomy	59.9	
Authentic*		.000
Chemistry	9.5	
Astronomy	49.2	
Pronoun*		.000
Chemistry	23.0	
Astronomy	3.0	
Number*		.000
Chemistry	60.0	
Astronomy	1.0	
Social*		.000
Chemistry	12.0	
Astronomy	1.0	
Discrepancy*		.000
Chemistry	4.0	
Astronomy	0.0	
Tentative*		.000
Chemistry	6.0	
Astronomy	1.0	
Certainty*		.000
Chemistry	4.0	
Astronomy	0.0	

Table 4 Continued

Affiliation*		.000
Chemistry	5.0	
Astronomy	1.0	
Question Mark*		.000
Chemistry	1.0	
Astronomy	0.0	

* $p < .01$

Chapter 3

The Relationship between Gender, Language, and Posting Type in an Online Course Discussion Forum

Introduction

Best practices in teaching online typically emphasize the need to provide a space for students to interact so that students can build community. Indeed, substantial work has been devoted to exploring the importance of developing community in online settings to prevent dropping out (e.g., Liu, Gomez, & Yen, 2009), raise course satisfaction (Drouin, 2008), strengthen cooperation (Barab et al., 2001; Hur & Hara, 2007), increase lines of support (Farooq et al., 2007) and promote feelings of belonging (Besser & Donahue, 1996) ultimately to aid learning (Rovai, 2002). Indeed, participation in discussion forums tends to be correlated with higher grades (e.g., Webb. Jones, Barker, & van Schaik, 2007; Palmer, Holt & Bray, 2008). Thus, in the context of online courses, discussion forums serve dual, intertwined purposes of creating community while also improving learning outcomes, which in turn makes them nearly ubiquitous in online courses.

Discussion forums may be particularly helpful for women in particular, given that women have relatively higher needs for affiliation (Drescher & Schultheiss, 2016), and the forums cater to this by assisting with community building through interaction. Leveraging these forums in Science, Technology, Engineering, and Math (STEM) courses may be especially beneficial to retaining women in these fields; doing so is crucial because women are significantly underrepresented in STEM fields (Hechtman et al., 2018). An AAUW (Corbett & Hill, 2015) report claimed, for example, that in 2013 “just 12 percent of engineers are women, and the number of women in computing has fallen from 35 percent in 1990 to just 26 percent today.”

Simply offering the discussion forums does not necessarily guarantee community formation or other positive outcomes for either men or women; instructors need to implement them thoughtfully to maximize outcomes (e.g., Salter & Conneely, 2015). And, once implemented, students need to engage with them productively. Negative outcomes are certainly possible from interacting with online course discussion forums. For example, the ways in which students engage with one another may preclude them from maximizing learning outcomes, especially if the language that they use is off-putting or disparaging, which often falls within traditional gendered language categories. Because of the ubiquity of gendered language (e.g., authoritative for men and polite or demure for women) and the possible consequences of using gendered language in online STEM discussion forums, this study examines gendered language used in discussion forums to understand if that particular aspect of engagement is related to learning outcomes. This study also investigates the influence of the context in which gendered language is used by examining gendered language's interaction with the varying foci of the discussion forum posts in relation to learning outcomes.

Literature Review

Online Learning for Women in STEM

The attrition rate for women in STEM programs often has been attributed to isolation (Blickenstaff, 2005; Hill, Corbett, St. Rose, & American Association of University Women, 2010). Margolis and Fisher (2002) point to a non-inclusive culture in STEM classes, leading to a sense of isolation and a lack of confidence, thus exacerbating the paucity of women in STEM. Online courses have the potential to incorporate features that have the ability to reduce feelings of isolation by promoting communities of learning (Lave & Wenger, 1991). Forum discussions explicitly tackle the issue of the isolated learner; they not only promote deeper understanding but

also may lead to feelings of belonging (Yuan & Kim, 2014). If women in STEM felt more welcomed, more empowered, and more connected in their introductory STEM college courses—which potentially can happen by increasing engagement in the discussion forums—the chances for eventual success in STEM could be improved for these students. Research on Massive Open Online Courses (MOOCs) suggest that women are comfortable participating in discussion forums, as they participate more than their male peers (Crues et al., 2018). Understanding the intricacies of how women interact on the discussion forums in online contexts other than in MOOCs will help researchers and practitioners understand the ways in which discussion forums can be leveraged to help women succeed in online STEM courses; for this reason, I turn to exploring the language that students use because the way in which an idea is expressed can either be inviting and community-building or off-putting and exclusionary.

Gendered Language Use and Discussion Forums

Numerous fields, including psychology, linguistics, communications, anthropology, and sociology, have investigated the ways in which self-identified men and self-identified women use language. The consensus is that, although more similar than not, there are measurable differences in men and women's use of certain features of language (Canary & Dindia, 2009). Patterned differences in words, phrases, and sentences have led researchers to categorize men's communication as generally dominant and aggressive (a "report" style of communicating) and women's communication as generally submissive and affiliative (a "rapport" style of communicating) (Tannen, 2007). Importantly, these styles signify power differences, leading to real-world power differentials between men and women in both the private and public spheres (Hall, 2004; McConnell-Ginet, 2004).

Such linguistic markings may then reveal one's social status (in this case, gender), thus influencing the collaborative experience. According to a social network perspective, social attributes carry with them stereotypes and power rankings. Cho, Gay, Davidson, and Ingraffea (2005) explain,

> Among the central premises of the social network perspective is the idea that some individuals may outperform their peers, because they occupy more structurally advantageous positions than others in social networks. In general, social network studies conducted in organizational settings demonstrate that network positions have significant impacts on individual and organizational outcomes because the structure of social interactions enhances or constrain access to valued resources such as task advice, strategic information, social supports, etc. (p. 8)

Given that students taking up and owning ideas originally presented by others is an important part to learning (e.g., Barron, 2000, 2003) and is what occurs on the discussion forums, examining the language used to share those ideas is crucial. Language, after all, has the potential to be a marker of one's social status, which in turn can influence students' reactions to and ultimately access to support and the sharing of information in the online environment (Cho et al., 2005).

Sullivan, Kapur, Madden, and Shipe (2015) sought to investigate whether gendered discourse would negatively affect collaboration in online science discussions. Although they found that each gender tended to abide by their discourse norms, the researchers did not find that the discourse styles influenced collaboration—specifically in terms of taking up one another's ideas. The researchers had hypothesized that ideas presented in terms of a female-discourse style would be ignored more than those ideas presented in terms of a male-discourse style, but they

found no gender bias. Such findings suggest that the online environment might moderate language's effects, or it might suggest that other gender markers, such as physical status, may be more likely to cause different reactions than language markers.

Discussion Forums and Interactivity

Language is only one component of understanding how discussion forums may help students succeed online. Another strand of research on online discussion forums focuses on the amount of times that students post to either voluntary (e.g., Cheng, Pare, Callimore, & Joordens, 2011) or required (Poole, 2000; Romero, Lopez, Luna, & Ventura, 2013) discussion forums in their online courses. These studies generally find that increased amounts of posting results in higher grades (e.g., Webb. Jones, Barker, & van Schaik, 2007; Palmer, Holt & Bray, 2008; Patel & Aghayere, 2006), and students who post more frequently also perceive that they are more satisfied with the courses and report learning more (Swan, 2001). Research on MOOCS also shows that forum participation predicts positive student outcomes, such as moderating course persistence (e.g., Crues et al., 2018; Gillani & Eynon, 2014; Kizilcec, Piech, & Schneider, 2013).

Technological Pedagogical Content Knowledge

Creating posts and interacting with others do not in and of themselves assure learning. Davies and Graff (2005) argued that the quality of the posts may determine learning outcomes. This quality may emerge from providing goal-based activities (Dennen, 2005) and overall structure (Garrison & Cleveland-Innes, 2010). Indeed, Salter and Conneely (2015) found that students are more engaged in discussion forums that provide a structure.

Developing forums that foster learning outcomes requires instructors' thoughtful use of each component of technological pedagogical content knowledge (TPACK), a term created by Mishra and Koehler (2006), derived from Shulman's (1986) pedagogical content knowledge.

They argue that teachers need to implement their understanding of which technological tools are appropriate for facilitating carefully selected pedagogical strategies to teach content. Using technology (e.g., implementing the use of online discussion forums) while ignoring the pedagogical knowledge piece (e.g., not thinking about how the forums should be structured for learning purposes) can easily result in misunderstandings of or disengagement with the selected content (Koehler & Mishra, 2009).

When, however, the forums are offered with intent, tied to goals, and serve as a conduit for delivering a pedagogical strategy, learning can flourish. For example, Dennan's (2005) study revealed that discussion forum activities involving perspective taking via sharing examples and making connections to outside concepts actually resulted in deep meaning making. Darabi, Arrastia, Nelson, Cornille, and Liand (2011) echoed this finding, explaining that reaching higher levels of critical thinking in discussion forums can happen by immersing students in authentic scenarios that require them to take different perspectives.

There is a need for even more studies to provide pedagogical guidance on how to structure online discussion forums for best learning outcomes (Loncar, Barret, & Liu, 2014). Toward this end, this study examines the results of thoughtfully and intentionally structuring forums using active learning strategies to produce deep learning within and between students. These pedagogical strategies include structuring the forums intentionally so that students ask questions, answer others' questions, and provide solutions to quiz-like homework problems. Each of these structures is rooted in research on best pedagogical practices, as described below.

Asking questions. Asking questions is often a sign that cognitive disequilibrium is present, which means that students may be experiencing contradictions between what they know and what they need to know or what they recently learned, thereby motivating them to resolve

the contradictions through problem solving, reasoning, and questioning. This process of restoring to a state of cognitive equilibrium allows the student to learn (Graesser & McMahen, 1993; Piaget, 1952).

Answering questions. The benefits of answering questions, which are posed by other students, derive from the positive effects that accrue from providing explanations (see, e.g., Jacoby, 1978; Slamecka & Graf, 1978). Having to engage in self-explanation and to teach others promotes understanding by refining knowledge and allows that understanding to transfer to multiple situations (McNamara, 1994; Pressley et al, 1992; Rittle-Johnson, Saylor, & Swygert, 2008). Answering questions that are focused on *why* and *how* can result in even greater explanations than answering questions focused on *what* and thus have the potential to lead to deeper processing (Craig, Sullins, Witherspoon, & Gholson, 2006).

Posting solutions to quiz-like homework problems. A potential benefit of this posting type lies in the way it takes advantage of the testing effect, by frequently engaging with and practicing the material. Doing so provides formative assessment, where both the instructor and individual students can evaluate what they do and do not understand (Roediger & Karpicke, 2006). Additionally, when solutions to the homework problems require the generation of answers rather than the recognition and selection of the answers from a list, students are much more likely to learn the material (Jacoby, 1978; McDaniel, Anderson, Derbish, & Morrisette, 2007). By posting publicly, students can solicit written feedback from other students and/or can compare their results with others to get feedback on what is going well and what needs improving.

Research Questions

To understand how and why women and men perform differently in online STEM courses, this study examines the structure of an online STEM course's discussion forum and drills down to look the use of gendered language within the forum. Specifically, I will examine:

Research Question 1: Do men and women differ in their language used on discussion forums? In other words, do I see differences in language use between men and women that might reflect and might promote student engagement and success in the course, as expressed through gendered language?

The next set of research questions focus on the differences between men and women, and between masculine and feminine language across the different structure of posts, allowed on the discussion forum: asking questions, answering another's question, or providing a solution to the quiz-like homework problems.

Research Question 2a: Do men and women use the different forum posting structures at different rates? This question gets at whether men and women behave similarly or differently as they navigate where to contribute to the discussion forums.

Research Question 2b: Do I see differences in masculine and feminine language used in the different forum posting structures? In other words, do I see language form (male- vs. female-typical language) follow function (posing a question, answering another's question, or solving a quiz-like homework problem)?

Research Question 2c: Do men and women differ in their language used across different forum posting structures? In other words, do I see differences in language use that might be sensitive to function of the post?

The next set of questions focus on which observed differences (between men and women; between masculine and feminine language; and between forum posting structure; and the interactions among these) are related to outcome (grade).

Research Question 3a: Do men and women differ in their final grades? In other words, do I see gender differences in learning outcomes in the online space in ways that have been reported for decades in traditional face-to-face learning contexts?

Research Question 3b: Is language use related to final grades? Here, I ask whether gendered language might differentially be predictive of grade, independent of whether the type of language was actually produced by a man or woman.

Research Question 3c: Is forum posting structure related to final grades? Here, I ask whether differentially contributing to the forums by asking questions, answering another's question, or providing a solution to the quiz-like homework problems predicts success in the course.

Research Question 3d: Is language use within each posting type related to final grade? Here, I ask whether gendered language use according to one's forum contribution (asking questions, answering another's question, or providing a solution to a homework problem) might differentially predict success in the course, as measured by final grade.

Method

Participants

Data for this study were collected from the discussion assignments from students enrolled in the Fall 2015, Spring 2016, Summer 2016, and Fall 2016 semesters of an introductory online chemistry course offered at a large Midwest university. Accounting for all four semesters, there were 368 total students enrolled, only 345 of whom were unique enrollees. (Eighteen students

had enrolled in two semesters and three students had enrolled in three semesters). There were 74 total drops, but because there were 8 students who had dropped the course twice across the four semesters, there were only 66 unique students who dropped (37 women and 29 men). This left 271 unique students who were enrolled for the entire semester. I had incomplete date for 24 of the students, leaving a total of 247 students for analysis (132 women and 115 men). Each semester's breakdown is as follows: Fall 2015 had 43 students (19 women, 24 men); Spring 2016 had 73 students (41 women, 32 men) Summer 2016 had 55 students (34 women, 21 men), and Fall 2016 had 76 students (38 women and 38 men). A Center for Innovation in Teaching and Learning (CITL) staff member with clearance to access FERPA-protected data took their discussion posts and replaced any personally identifiable information with a random hash and created a key detailing the gender that corresponded with each of the random hashes.

Data Set

Students generated 3,404 posts throughout the four semesters that stemmed from 13 discussion assignments, one for each week of material. Participation in the discussion assignments accounted for 5% of the students' final grades. The assignments entailed the following: Each week, the instructor created 4-5 discussions forums, with each forum consisting of an exam-like problem. The students chose in which forum to participate, and then they were required to either (a) post a *solution* to the initial problem, (b) post a *question* about the problem, or (c) *answer* a question that had been posted by another student to the forum. Students were required to do only one of the aforementioned activities and on only one of the forums each week, although they were permitted to participate more if they chose to do so. The instructor's intended goal of this assignment, as posted on the syllabus, was to have students "learn how to

approach challenging problems from other student explanations, and by teaching other students."

Data Analysis

Gender. Students were classified as being male or female, based on self-identification data when enrolling at the University. The number of students who did not select male or female was too small to meet FERPA requirements for data analysis, and thus these individuals were not included in this study.

Grades. To comply with FERPA requirements and ensure that students' identities would not be revealed, final grades were collapsed from A, B, C, D, F, and W (withdraw) into two categories: students were classified as earning either (1) an A or B or (2) a C or below.

Posting type. I classified each post as a solution, question, or answer (see definitions provided in Data Set) by considering the reply depth of a post in the discussion thread as well as whether a question mark was present. If a question mark was present, the post was coded as a question, despite the reply depth. If the post did not contain a question but was the first statement in a thread, it was coded as a solution. If the post did not contain a question mark and appeared in at least the second level of reply depth of the discussion thread, I counted it as a solution. I chose to code students' posts using this method because it was efficient relative to hand coding 3,404 individual posts and obtaining inter-rater reliability. I coded 20% of the postings by hand (human coding) for their reply depth and compared this to the automated coding (machine coding). Reliability between the human and machine coding indicated substantial agreement (Landis & Koch, 1977), Cohen's (1960) $\kappa = .75$.

The posting types are mutually exclusive; therefore, each post could only belong to one of the three types. I then aggregated the number of solutions, questions, and answers by student across the semester to give each student a total score for each category.

Text analysis. To analyze the gendered language employed in the discussion forums, I used Linguistic Inquiry and Word Count 2015 (LIWC; Pennebaker, Booth, Boyd, & Francis, 2015), a computerized text analysis program in its third iteration that outputs the percentage of words in a given text that fall into one or more of over 80 linguistic (e.g., pronouns, conjunctions), psychological (e.g., anger, achievement), and topical categories (e.g., money, health, and religion). The corpus used to derive these categories consists of more than 500,000 texts that range from tweets to novels.

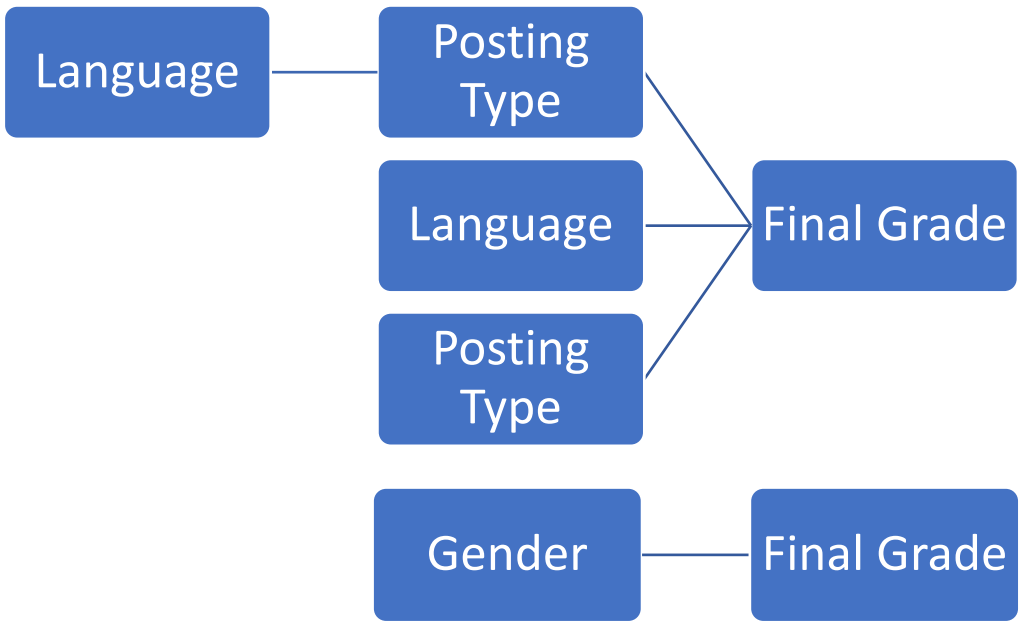
A major addition to the 2015 version of LIWC is the inclusion of four summary variables empirically developed in the research labs of the LIWC team: analytical thinking (Pennebaker et al., 2014), clout (Kacewicz et al., 2012), authenticity (Newman et al., 2003), and emotional tone (Cohn et al., 2004). Based on the relation to previous research, I included three of the four newly added summary variables: analytic thinking (e.g., being critical and presenting logical thinking), clout (e.g., showcasing confidence and expertise), and authenticity (e.g., displaying openness and honesty). Unlike the other categories that LIWC captures, LIWC generates a rating, rather than a count, for each of these summary categories. Examples of these LIWC categories as well as the non-summary categories used in this study are in Table 10 of the Supplementary Information section at the end of the document.

Each individual post was analyzed for its LIWC categories. Then, within student and for each posting type, I calculated the average scores for the LIWC categories of interest. This resulting in assigning each students' posting type (solution, question, and answer if they posted all three throughout the semester) an average score for each LIWC category of interest.

Results

I present the results as answers to the research questions posed earlier. Each question contributes to understanding how gender, aspects of language (as measured by LIWC categories), and posting type are related to final grade. All questions use data from across all semesters because no differences were found between them. Below, I describe the tests used to answer each question. The questions build on one another, but a model incorporating all variables would violate assumptions of independence. Thus, I tested each question individually, performing tests that do not violate the assumptions of independence. Figure 1 is an overview of the final relationship between the variables. Tables 5-9 present descriptive statistics for the research questions. Note that the analyses of the three summary variables (*Analytic*, *Clout*, and *Authenticity*) are based on overall ratings on a scale of 1-100, where as the non-summary variables (*Word Count*, *Pronouns*, *Discrepancies*, *Tentative*, *Social Processes*, *Numbers*, and *Certainty*) are based on counts, representing the number of occurrences that each category appears.

Figure 1



Research Question 1: Do males and females differ in their language used on discussion forums?

I used the Kruskal-Wallis one-way analysis of variance test on all LIWC categories to test for a relationship with gender. There were no gender differences among any of the categories.

Research Question 2a: Do men and women post to the different forum structures at different rates?

I used the Kruskal-Wallis one-way analysis of variance test to test whether the number of questions, answers, and solutions posted varied by gender. There was no difference between men and women. The test statistics for each posting type are as follows: asking questions, χ^2 (1) = 2.405, p =.121; answering questions, χ^2 (1) = 2.799, p =.094; posting solutions, χ^2 (1) = .145, p =.704.

Research Question 2b: Do differences in masculine and feminine language exist between the different posting types?

Next, I investigated whether language differed for each posting type. The medians of each LIWC category by posting type are in Table 5. I ran a Related-Samples Friedman's Two-Way Analysis of Variance test to determine if there were differences in the LIWC categories employed within different posting categories. Language use was statistically significantly different between posting types for all categories except for clout: *Word Count:* χ^2 (2) = 33.38, p < .01, *Analytic*: χ^2 (2) = 52.74, p < .01, *Authentic*: χ^2 (2) = 43.98, p < .01; *Pronoun*: χ^2 (2) = 63.02, p<.01, p < .01, *Number*: χ^2 (2) = 61.63, p < .01, *Social*: χ^2 (2) = 63.10, p < .01, *Discrepancy*: χ^2 (2) = 21.56, p < .01; *Tentative*: χ^2 (2) = 29.12, p < .01; *Certainty*, χ^2 (2) = 25.45, p < .01, and *Question Marks*, χ^2 (2) = 30.45, p < .01. With the exceptions of *Analytic* and

Number, every category was used significantly more when asking questions compared to answering questions or posting solutions. The two features that were not used more when asking questions, *Analytic* and *Number*, were used significantly more when posting solutions, compared to both asking questions and answering questions.

Research Question 2c: Do men and women differ in their language used across different posting types?

A Friedman test, split by gender, revealed very few differences between men and women's use of language across posting type. The counts of the non-summary LIWC categories for each posting type by gender are found in Table 6. The medians of each LIWC category, shown separately for men and women, are in Table 7. Men and women behaved similarly in their use of language across all LIWC categories with the exception of females' use of *Authentic* language across the three posting types, χ^2 (2) = 7.18, $p < .05$, in which they used significantly less *Authentic* language when posting solutions compared to the other posting types. The same Friedman test also revealed a significant difference in females' use of *Tentative* language [χ^2 (2) = 18.88, $p < .01$], *Certainty* [χ^2 (2) = 11.34, $p < .01$], and *Affiliation* [χ^2 (2) = 29.78, $p < .01$]. In all three instances, women used more of that language when asking questions than when answering questions or posting solutions. Women used the other LIWC categories at similar rates across the posting types.

Research Question 3a: Do men and women differ in their final grades?

Among all students who completed the course across all semesters, there were 120 final grades of an A or B and 127 final grades of a C or below. A χ^2 test indicated that the high grades and low grades were not equally distributed in the population, χ^2 (1) = 9.18, $p < .01$. Men were more likely to earn a grade of A or B (N=71, 62% of men) than a lower grade; women were less

likely to earn a grade of A or B (N=56, 42% of women) than a lower grade. Now that I know that men were more likely to earn higher grades than women, I can explore which features of participation (contributing different types of posts and using different types of language) was associated with gender and with higher grades.

Research Question 3b: Is language use related to final grades?

I conducted a Kruskal-Wallis test to determine if there was a relation between use of certain features of language, as measured by LIWC, and final grade outcomes. The medians of each LIWC category as delineated by grade are in Table 8. The medians for the following LIWC categories were statistically significantly higher for students earning an A or B as compared to those earning a C or below: *Word Count*: $\chi 2$ (1) = 17.646, p < .01, *Pronoun*: $\chi 2$ (1) = 7.634, p < .01, *Number* $\chi 2$ (1) = 14.537, p < .01, *Social* $\chi 2$ (1) = 9.049, p < .01, *Discrepancy* $\chi 2$ (1) = 9.278, p < .01, *Tentativeness* $\chi 2$ (1) = 8.336, p < .01, *Certainty* $\chi 2$ (1) = 5.475, p < .05, *Affiliation* $\chi 2$ (1) = 14.681, p < .01.

Research Question 3c: Is posting type related to final grades?

I used a Kruskal-Wallis test to determine if posting type was related to final grade. Posting solutions was significantly related to earning a grade of an A or B, $\chi 2$ (1) = 4.297, p < .05, as was answering others' questions $\chi 2$ (1) = 7.692, p < .01. Asking questions was not significantly related to final grade.

Research Questions 3d: Is language use within each posting type related to final grade?

A Related-Samples Friedman's Two-Way Analysis of Variance test was run to determine if there were differences in grade for the LIWC categories employed within different posting categories. The medians of each LIWC category by posting type and grade are in Table 9. The test revealed a significant difference in the *Authentic* language used within each posting type for

earning a Grade of C or below, χ^2 (2) = 15.55, p < .01; specifically, students earning a lower grade used *Authentic* language much more when asking questions and answering others' questions. Students who earned lower grades also used *Numbers* significantly differently across posting types: χ^2 (2) = 15.55, p < .01. Conversely, students who earned an A or B generally used *Numbers* equally across posting types. Finally, students who earned lower grades also significantly used *Tentative* language differently across the posting types: χ^2 (2) = 14.44, p < .01. They used this language much more frequently when asking questions as compared to posting solutions or answering questions. No grade differences were found for other posting types within each of the grade categories; rather language was used in similar ways across posting types within each grade category

Discussion

This study examined the interplay between gender, language, and posting types as well as the relationship of each of these to final grade. Surprisingly, the use of gendered discourse was not related to a student's gender, although elements of gendered discourse permeated the discussion forums. Gendered language, however, significantly related to what type of post the student produced and also was related to students' final grades. The study built on questions pertaining to (a) gender and language and (b) language and posting types to ultimately explore how (c) gender, language and posting types related to final grades.

Ways in Gender and Gendered Language Relate to Grades

Our study was not in line with previous studies' findings of women performing significantly better in online courses than men (e.g., Xu & Jaggars, 2014). In this particular online course, women performed worse than men in terms of final grade, just as they do in face-to-face classes (Xu & Jaggars, 2014).

As a whole, women did not use a rapport style of communication, and thus this does not seem to be a reason for their lower performance, as originally hypothesized. Perhaps the course structure—and particularly the structure required for posting to the forums—plays a greater role in use of gendered language than a student's gender. If this is the case, replicating the structure of the forums in other courses (especially with different STEM content) could provide insight into how gendered language plays a role—or not—in online STEM college courses.

The only way in which women's language use differed from men's language use was in women's differential use of *Authentic, Tentative, Affiliation,* and *Certainty* across posting type; meanwhile, men did not differ in their use of those categories across posting type. In the instance of *Authentic* language, women used such language more when posting solutions than with the other posting types. Interestingly, as explored in Research Question 3d, using authentic language while posting solutions was not associated with final grade. Thus, their use of *Authentic* language for this posting type is not of major consequence in terms of grade potential.

Furthermore, women used more *Tentative* language and language of *Affiliation* as well as *Certainty* when asking questions compared to their other posting types. Important to note is that, as explored in Research Question 3C, question asking as a whole was not related to final grade. Thus, again, females' linguistic engagement within this posting type is not of major concern in terms of final grade consequence. Moreover, although I found differences in these categories, the overall frequency was quite low, which further suggests that these categories may not be of practical significance. There is one caveat from Research Question 3d's findings, however: I found a relationship between earning lower grades and the use of tentative language while asking questions. I explore the relationship between language and posting type in the next section.

Language and Posting Types

Although a student's gender was not predictive of their overall use of female-typical or male-typical language in this sample, the use of gendered language was related to posting type. This suggests that students were using language in very purposeful ways according to their needs. Indeed, with the exception of clout, all 12 other language categories were used differentially across the three posting types.

This differential use of language within certain posting types was related to final grade. This was only true for students who earned lower grades; interestingly, students who earned higher grades did not use language differently across posting types.

Of note is that students who earned a lower grade used *Numbers* significantly more for posting solutions compared to asking questions and answering questions. The inclusion of *Numbers* adds a level of specificity and detail to students' posts; that these students did not have as much detail in the other posting types may be indicative of their level of understanding of the material, particularly because this course centers so much on the use of *Numbers*. A practical implication of this finding is that instructors would benefit from offering students specific advice about using *Numbers.* They should encourage students to use *Numbers* in all posting types, much like they are doing when posting solutions. Encouraging students to include *Numbers* when asking and answering questions would give them one avenue for making the posts deeper, which in turn has the potential to help with their final grade. This advice is helpful for courses that have heavy numerical components, but instructors of other STEM courses that do not have many formulas, equations, or calculations may need to focus on other, more relevant LIWC categories to survey the level of specificity that students have in their posts.

Additionally, students who earned lower grades used *Authentic* language more when asking questions and answering questions. This level of openness in the posts could in part be due to the disclosure of not being sure of the content that they are posting. Reaffirming this hypothesis is that these students also used *Tentative* language when asking questions. The results indicate that instructors might be able to impact their students' success by paying particular attention to the use of *Authentic* language when students are answering questions and asking questions. Given that these disclosing and honest students tend to earn lower grades, but simply asking a question was not related to earning a lower grade, paying attention to these features of language use could be a crucial alert to instructors. It is encouraging that when students are clear enough to know that they have a lack of knowledge, they post this uncertainty. The next step would be to make instructors aware of this so that instructors can be sensitive to when students are using *Authentic* language so that they can intervene and provide those students with more support.

The same is true of students' use of *Tentative* language, particularly when asking questions, and of note is that women tended to use this language when asking questions as compared to the other posting types, unlike their male peers. Intuitively it makes sense that when students ask questions, they add hedges like "could," "maybe," "possibly," and "I think." This makes the language less direct and more vague, however, which means that their questions are not as well-formed or well-thought out as their higher-grade-earning peers. Asking questions is an important part of learning, but having well thought-out questions makes for even more productive learning outcomes (Craig, Sullins, Witherspoon, & Gholson, 2006). Training students—perhaps with a special alert to women—how to ask questions that are more reflective,

deep, and definite might guide these students to receive the most benefit from asking the questions in the first place.

Across both grade categories and posting types, word count was related to final grade. Instructors should take note of this and might get students to think more deeply about the course content by requiring a minimum word count. My hypothesis, based on the results from this investigation, is that requiring a relatively high word count could push students to explore their thoughts and be more thorough in their explanations; however, this is only a hypothesis and both experimental and quasi-experimental investigations in which students are required to produce different word counts, and seeing if this produces better explanations, would be warranted before broadcasting to instructors that they implement this in their online STEM courses.

Posting Types

Asking more questions was not associated with final grade, but posting solutions and answers to other students' questions was associated with earning a higher grade. Thus, in helping students be more successful in online courses, instructors may consider requiring at least some minimum number of posts that provide solutions to homework problems or answering students' questions.

Limitations and Future Directions

This study is purely correlational in nature, making some of the directionality of the results unclear. For example, it is not clear if using *Tentative* language when asking questions results in lower grades, or if being on the path to earning a lower grade results in using more *Tentative* language when asking questions.

Gathering even more background information on students would provide more variables to control for, thereby providing even more information on why the observed correlations may

exists. Such variables include students' previously taken courses, reasons for taking the course, major, ACT score, comfort with technology, and number of online courses previously taken. By incorporating these background variables into predicting success, I can come closer to understanding how background and course features work separately and together to impact students' success in online STEM college courses.

Likewise, this study only considered data from one course, which was introductory and a requirement for many majors. Future studies should examine courses with a similar structure that are at other course levels (i.e., upper level) and that also cover other topics besides chemistry. This will provide for a better understanding of how generalizable the results of this study are. Importantly, this study relied on automated means of examining both posting type as well as gendered language. Exploring the context surrounding the use of *Numbers* as well as *Authentic* and *Tentative* language, which may best be done with human rather than machine coders, may enhance explanations as to why these language categories were associated with lower grades for certain posting types.

Finally, future studies also need to examine the question-asking posts to understand why this posting type was not associated with final grade. Those students who are struggling the most with the material are likely to have more questions and thus could earn a lower grade, but students who have high enough metacognitive awareness and reflectivity to engage in help-seeking behavior may ask questions and earn a higher grade. Examining question-asking patterns across the semester to see if the number of questions diminishes and also if the questions get answered is important in better understanding this piece. Follow-up studies may also examine the depth of the questions to see if richer questions actually are associated with higher grades (as is speculated here, based on the language used).

Conclusion

This study took a granular approach to examining how discussion forums may help students' course outcomes. Specifically, it explored how gender, language, and posting type related to final grade. Language use was not split across gender lines nor was posting type, but gender and posting type were both related to final grade; thus, the language that women use as a whole and the posting types in which they engage as a whole are not necessarily a contributor to their lower grades. These findings provide even more evidence that students' behavior in the online environment is different than in the face-to-face environment, and they highlight the need for more research to examine why the online environment is or is not effective for various demographics.

Tables

Table 5

Median Counts of LIWC Categories Across Semester by Posting Type

LIWC Category	*M*dn	*p* value
Word Count*		.000
Questions	52.0	
Answer	31.7	
Solution	43.6	
Analytic*		.000
Questions	53.3	
Answer	64.9	
Solution	85.4	
Clout		.245
Questions	50.0	
Answer	53.2	
Solution	48.0	
Authentic*		.000
Questions	41.3	
Answer	30.5	
Solution	17.0	
Pronoun*		.000
Questions	6.5	
Answer	3.4	
Solution	2.1	
Number*		.000
Questions	1.6	
Answer	2.0	
Solution	7.8	
Social*		.000
Questions	3.0	
Answer	1.6	
Solution	0.9	
Discrepancy*		.000
Questions	0.8	
Answer	0.4	
Solution	0.3	
Tentative*		.000
Questions	1.3	
Answer	0.6	
Solution	0.5	
Certainty*		.000
Questions	0.7	
Answer	0.3	
Solution	0.3	
Affiliation*		.000
Questions	1.2	
Answer	0.3	

Table 5 Continued

	0.3	
Solution		
Question Mark*		.000
Questions	0.4	
Answer	0	
Solution	0	

Table 6

Number Counts of Non-Summary LIWC Categories Across Semester by Posting Type, Split by Gender

LIWC Category	Women *N*	Men *N*
Total		
Questions	273	155
Answer	484	326
Solution	920	963
Word Count		
Questions	15424	8856
Answer	16746	11701
Solution	37827	42037
Pronoun		
Questions	1957	990
Answer	1802	1131
Solution	1903	2399
Number		
Questions	898	631
Answer	1490	1160
Solution	7220	7024
Social		
Questions	906	537
Answer	985	548
Solution	845	976
Discrepancy		
Questions	241	128
Answer	341	142
Solution	369	414
Tentative		
Questions	357	225
Answer	354	188
Solution	554	613
Certainty		
Questions	303	116
Answer	179	111
Solution	301	367
Affiliation		
Questions	300	224
Answer	333	205
Solution	406	477

Table 6 Continued

Question Mark		
Questions	158	78
Answer	89	50
Solution	169	155

Table 7

Median Counts of LIWC Categories Across Semester by Posting Type, Split by Gender

LIWC Category	Women *M*dn	*p* value	Men *M*dn	*p* value
Word Count		.000		.035
Questions	53.8		49.0	
Answer	28.6		33.1	
Solution	41.1		45.7	
Analytic		.000		.001
Questions	52.1		60.9	
Answer	64.9		65.4	
Solution	85.3		85.5	
Clout		.507		.120
Questions	50.4		48.9	
Answer	53.5		50.0	
Solution	47.2		49.1	
Authentic*		.005		.113
Questions	43.5		39.5	
Answer	34.2		26.9	
Solution	15.9		17.3	
Pronoun		.000		.001
Questions	7.2		6.0	
Answer	3.5		3.5	
Solution	1.9		2.4	
Number		.009		.028
Questions	1.7		1.5	
Answer	1.8		2.5	
Solution	8.0		7.6	
Social		.000		.004
Questions	3.0		3.0	
Answer	1.7		1.6	
Solution	0.8		0.9	
Discrepancy		.001		.011
Questions	0.8		0.8	
Answer	0.5		0.3	
Solution	0.3		0.3	
Tentative*		.000		.325
Questions	1.3		1.3	
Answer	0.6		0.6	

Table 7 Continued

Solution	0.5		0.6	
Certainty*		.003		.065
Questions	0.7		0.6	
Answer	0.3		0.3	
Solution	0.2		0.3	
Affiliation*		.000		.174
Questions	1.2		1.3	
Answer	0.3		0.4	
Solution	0.3		0.4	
Question Mark		.221		.613
Questions	0.5		0.2	
Answer	0.0		0.0	
Solution	0.0		0.0	

Table 8

Median Counts of LIWC Categories Across Semester by Grade

LIWC Category	*M*dn	*p* value
Word Count*		.000
A/B Grade	582	
C or Below	315.5	
Analytic		.097
A/B Grade	86.5	
C or Below	82.9	
Clout		.057
A/B Grade	50.0	
C or Below	47.6	
Authentic		.214
A/B Grade	7.2	
C or Below	11.2	
Pronoun*		.006
A/B Grade	37.0	
C or Below	16	
Number*		.000
A/B Grade	73.0	
C or Below	42.5	
Social*		.003
A/B Grade	16.0	
C or Below	6.0	

Table 8 Continued

Discrepancy*		.002
A/B Grade	6.0	
C or Below	3.0	
Tentative*		.004
A/B Grade	8.0	
C or Below	4.0	
Certainty*		.019
A/B Grade	5.0	
C or Below	3.0	
Affiliation*		.000
A/B Grade	7.0	
C or Below	2.0	
Question Mark		.655
A/B Grade	1.0	
C or Below	1.0	

*p< .01 ** p < .05

Table 9

Median Counts of LIWC Categories Across Semester by Posting Type, Split by Grade

LIWC Category	*M*dn	*P* value
A/B GRADE		.002
Word Count		
Questions	55.35	
Answer	35.8	
Solution	49.0	
C or Below GRADE		.005
Word Count		
Questions	46.0	
Answer	28.1	
Solution	41.2	
A/B GRADE		.011
Analytic		
Questions	60.8	
Answer	66.4	
Solution	85.7	
C or Below GRADE		.001
Analytic		
Questions	50.4	
Answer	62.9	
Solution	82.2	
A/B GRADE		.119
Clout		
	54.0	

Table 9 Continued

Questions		
Answer	54.8	
Solution	48.6	
C or Below GRADE		.664
Clout		
Questions	45.0	
Answer	50.0	
Solution	47.4	
A/B GRADE		.309
Authentic		
Questions	33.1	
Answer	28.0	
Solution	16.7	
C or Below GRADE*		.000
Authentic		
Questions	47.3	
Answer	37.4	
Solution	17.5	
A/B GRADE		.000
Pronoun		
Questions	7.0	
Answer	3.7	
Solution	2.3	
C or Below GRADE		.000
Pronoun		
Questions	6.4	
Answer	3.2	
Solution	1.9	
A/B GRADE		.134
Number		
Questions	2.0	
Answer	2.6	
Solution	8.3	
C or Below GRADE*		.000
Number		
Questions	1.4	
Answer	1.3	
Solution	7.4	
A/B GRADE		.000
Social		
Questions	3.0	
Answer	1.7	
Solution	0.9	
C or Below GRADE		.000
Social		
Questions	2.9	
Answer	1.2	
Solution	0.8	

Table 9 Continued

A/B GRADE		.003
Discrepancy		
Questions	1.0	
Answer	0.4	
Solution	0.3	
C or Below GRADE		.004
Discrepancy		
Questions	0.8	
Answer	0.4	
Solution	0.4	
A/B GRADE		.066
Tentative		
Questions	1.2	
Answer	0.7	
Solution	0.6	
C or Below GRADE*		.001
Tentative		
Questions	1.4	
Answer	0.6	
Solution	0.5	
A/B GRADE		.005
Certainty		
Questions	0.5	
Answer	0.3	
Solution	0.3	
C or Below GRADE		.028
Certainty		
Questions	0.7	
Answer	0.3	
Solution	0.3	
A/B GRADE		.000
Affiliation		
Questions	1.3	
Answer	0.5	
Solution	0.4	
C or Below GRADE		.004
Affiliation		
Questions	0.8	
Answer	0.2	
Solution	0.3	
A/B GRADE		.055
Question Mark		
Questions	0.6	
Answer	0.0	
Solution	0.0	
C or Below GRADE		.946
Question Mark		

Table 9 Continued

Questions	0.3
Answer	0.0
Solution	0.0

Chapter 4

Conclusion

This dissertation explored the role of gendered discourse in online STEM discussion forums to contribute to a broader understanding of why women may or may not be successful in online STEM courses. The first study endeavored to describe the state of gendered language in two online discussion forums. The second study explored the relationship between gender, gendered language, posting types, and final grades. The following describes key highlights of the studies' findings and also explores the studies' limitations while subsequently positing future directions.

Summary of Findings

These studies have made two important contributions. First, much research has shown that forming a community through discussion forums is important for students to be successful in online courses; few studies, though, have examined the granular mechanisms by which this community forms. In the investigations reported here, I sought to understand one potential mechanism: language. In particular, I investigated whether language with female-gendered-language markers (i.e., markers that distinguish male from female speakers, typically used by women, e.g., politeness) was actually used more by women than men (Chapter 2) and whether or not these markers were associated with evidence of success in the community (i.e., better grades; Chapter 3). I also investigated whether male-gendered-language markers (e.g., *Clout*) were used more by men than women and whether or not these were associated with evidence of success. The rationale for this was based on the idea that language has the ability to influence community formation because of the social markers that it can embody (Cho, Gay, Davidson, & Ingraffea, 2005).

Surprisingly, the first study revealed that the language used in an online discussion forum may not actually reflect one social marker—the gender of the student. Indeed, neither men nor women overwhelmingly used one type of gendered language (of the 13 gendered language markers examined in this study). The implication of this finding is that, by disassociating language from gender, all students may be able to interact with one another on an as-needed basis, without the typical constraints imposed by gender. In addition, this potentially may serve to limit an emphasis of their gender, thereby potentially limiting the ramifications that may surface because of their gender, including the intentional and unintentional access to support and the sharing of information in the online environment (Cho, Gay, Davidson, & Ingraffea, 2007).

Driven both by the surprising finding that men and women use equal amounts of gendered language in their discussion posts in online STEM courses and that understanding how to support productive use of online discussion forums is of the utmost importance, in the second study (Chapter 3), I sought to investigate how the structure of the discussion forums was related to gendered language and success in the course. In exploring three active learning strategies that discussion forums can offer (e.g., practicing material by posting solutions to homework problems, reflecting on one's understanding and asking questions, and engaging in explanation by answering someone's questions), the second study highlights which ones may be more beneficial for learning. Specifically, I found that posting solutions and answering others' questions showed significant relations to getting a good grade. Incorporating higher *Word Counts, Numbers* and *Analytic* language was particularly helpful for these posting types.

Implications for Instructors

These studies showcase the need for instructors to pay attention to the language that students use; doing so will help instructors have a better understanding of the state of community

and their students' grasp of the material, thereby enabling them to offer supports when students give indications of struggling. For example, the second study found that students that use more *Authentic* language tend to earn lower grades. This language is indicative of openness and honesty, and as a result means that students potentially could be openly stating concerns that they have. Thus, when instructors see such language, they should pay special attention to the content of the students' posts to see if they can benefit from support materials.

Importantly, instructors should be cognizant of the pedagogical consequences of the choices they make. If thoughtful, they can structure discussion forums in ways that support learning outcomes both directly (by ensuring students are actively learning) and indirectly (by helping foster community development). Based on the results of Study 2, instructors may want to consider having students post answers to others' questions or post solutions to homework problems; a followup study in which students are randomly assigned to create specific types of posts can speak more to this suggestion. Likewise, a followup study can investigate the impact of teaching students how to ask reflective, thoughtful questions to support final grades.

Limitations and Future Directions

Although this research has made headway in understanding gendered discourse in the online environment, the findings should be triangulated using other methods. These studies analyzed gendered language using categories in LIWC that correspond with Tannen's (1997) research on gendered discourse. Coding discussion forums by hand for gendered language features and comparing these findings to the automated findings would validate the usefulness of programs like LIWC for exploring gendered language. Being able to use easily accessible, widely used text analysis programs like LIWC opens the door to analyzing larger data sets and

getting more powerful results through a standardize measurement that can be more easily generalized.

Although LIWC is very beneficial, it must be noted that LIWC's current corpus does not include samples from class discussion forums. Rather, blogs, expressive writing, novels, natural speech, newspaper articles, and tweets from Twitter currently comprise the LIWC corpus. While this study has the potential to expand LIWC's usefulness, more studies on class discussion forums must be conducted to establish the validity of LIWC in this context. The word count itself should not be a hindrance on the validity of using LIWC on discussion forums, however, as the posts falls within LIWC 2015's suggested parameters of at least 25 words or more (Pennebaker, Boyd, Jordan, & Blackburn, 2015). Additionally, the majority of posts are longer than a Twitter feed, which, even at 160 characters or less, have been reliably analyzed (e.g., Dzogang, Cristianini, & Lightman, 2018).

Assuming the online environment does invoke different language choices, more research needs to examine the influence of the topic and course level. The first study in this dissertation sought to answer whether gendered language was used in similar ways across STEM courses. Only two STEM courses were part of the analysis and they were different from one another in that the chemistry course was introductory level and required for many majors, whereas the astronomy course was upper-level and an elective. By comparing different course levels within the same course topic and also by comparing different topics across within one course level, I can gain a better understanding as to whether gendered language is indeed used in the same capacity across STEM courses.

Likewise, examining the interplay between students' background knowledge (potentially measured by previous courses taken, ACT score, major, technology experience, etc.) will help

unpack the relationship between language and final grade. It could be, for example, that the language that is related to better grade outcomes is only being used by students who are really comfortable with the course material because they have taken a similar course before. In this situation, they may feel like they can let their guard down and write in a more conversational manner, while still being confident in what they say.

In these studies, I only analyzed courses in which participation in the discussion forums were required. It is possible that voluntary discussion forums contain different content, in part because they are more loosely structured. Comparing the language on voluntary vs. required forums in online STEM courses, even within the same course, may reveal very different language patterns that could provide insight on the best way to form community. Although the required forums likely help form community—especially when structured in certain ways that support interaction—it may be that voluntary forums provide a means for students to build more intimate, trusting relationships than in required forums, which carry over to the required forums. Building such relationships allow students to feel supported and feel like they belong, which in turn can help with course retention—a particularly important piece to ultimately helping women get jobs in STEM fields.

In the studies reported here, I only looked at students' corpus of contributions to the course forums. Future work should examine language's role in community formation *over time*. Doing so can help answer if students who use similar language end up gravitating toward one another when talking on the forums, and it can pinpoint language that is isolating and results in students who never get responses.

Lastly, language is by no means the sole contributor of community formation. A future more robust view of community formation will use social network analyses to not only examine

how language affects community formation but also how student characteristics (e.g., race, gender, major, background knowledge, etc.) influence community formation. students' background knowledge and demographic features to understand how those play a role in community formation over time.

Conclusion

In terms of helping females be more successful in online STEM courses, these studies are promising. They reveal that gendered language is not being used strictly along gendered lines, which means that women are not being marked as women through the use of gender-typical language forms. This result potentially erases traditional barriers for community formation (especially those reported by women in STEM) and, ultimately, for learning. Continuing to investigate the factors that enable this success will allow for researchers and instructors alike to capitalize on them and do their part to help level the STEM playing field.

Supplementary Information

Table 10

Examples of each LIWC Category

LIWC Category	Example
Analytic	For 29, you have to use the equation lnk = -Ea/R(1/T) + lnA. Slope is equal to -Ea/R and the intercept is equal to lnA. Thus, your equation should look like this now: lnk = -917(1/T) + -.441 Next, you need to [find] k by plugging in the temperature given in the problem. Once you have k, then you can plug it into the differential rate. The rate of the equation depends on which order your problem is in. Hope this helps!
Clout	I solved for K, which was 0.2963 after rounding Lastly I plugged everything in to the DeltaG equation (CONVERT -2.00kJ into Joules) DeltaG= (-2000)+(8.314)(298K)In(0.2963)= -5013.68, divide by 1000 to convert back into kJ DeltaG= -5.014kJ which equals maximum work able to be put in.
Authenticity	What kind of tripped me up at first was trying to figure out what to do with the amount of water we're given. You have to go back in your brain and remember that molarity=moles/liters, and that the concentration of H+ is molarity. [ac1dbe8447] by multiplying the concentration by the mL of water given, you can get moles.
Pronoun	Almost this same question was on the recent quiz, yet *we* weren't given DG standard. *I* was trying to find it using other equations, but *I* couldn't quite figure it out. *I* know how to complete this problem, *I* just couldn't when *I* wasn't given that part. Was there something *I* was missing?
Numbers	G = Go + RT lnQ BUT since its equilibrium lnK is used (which I forgot). A<-->B = 1.0M G= -1.85kJ Go= -5.15kJ

Table 10 Continued

	R= 8.314 T=279KK...I did an ICE table-- A <----> B I 1.0. 1.0 C -x +x E. 1.0-x 1.0+x Plug in: -1.85 = -5.15 + (.008314)(279)(ln(1.0+x/1.0-x) 1.423 = ln (1.0+x/1.0-x) e^ to get rid of ln 4.148 = 1+x/1-x 4.148-4.148x = 1.0+x [ac1dbe8447] 3.148 = 5.148x [ac1dbe8447] 3.148/5.148 = x x = .61149 (the answer was .612, woo!!) Is there another way to find k without the ICE table?
Social	Nice to *meet* you! If you need *help* with anything, I'm always willing to *help*! I can't imagine having a language barrier. I would do anything I can to *help*!
Discrepancy	I think the concentration of oxygen *would* have to play a role if we dipped it into liquid oxygen. If you have more concentration of oxygen the cheat [c09c2dfae0] burn much faster. We *could* also increase the temperature to increase the rate of the burning of the cheeto also.
Tentative	I *don't think* you can use the equation because there is an acid and a base but the conjugate is not present. *I think* you just figure out what is left over and figure the pH or depending on what species is left. Hope this helps!
Certainty	Yes Kw is *always* neutral for water. Water is neutral and Kw is the constant for water in equilibrium. The fact that it is the constant for water means that it will *always* be neutral even the PH number is slightly below 7 or above.
Affiliation	Because the given model is given in y=mx+b *we can relate it* to the model ln(k)=(-Ea/R)(1/T)+ln(A) this gives us -2080=(-Ea/R) if R=8.314 we get Ea= 17.29 kJ and *we also know* ln(A)= -0.2984 *letting us* calculate A=0.742

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